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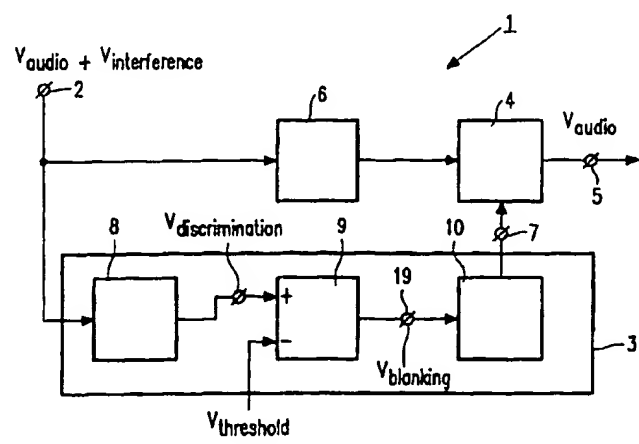
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(54) Title: INTERFERENCE DETECTION CIRCUIT HAVING AMPLITUDE FREQUENCY DOMAIN DEFINED DISCRIMINATION



(57) Abstract

An interference detection circuit is described comprising means, in particular non linear means, for defining a discrimination curve in terms of instantaneous magnitude and instantaneous frequency, and means, in particular differential amplification means, for detecting whether a combination, in particular the product, of said instantaneous magnitude and said instantaneous frequency of the inputted signal exceeds the discrimination curve in which case control means control the gating of the inputted signal. The discrimination defining means have a control input for adaptation of the discrimination curve to the average instantaneous magnitude, in particular the product of the instantaneous magnitude and the instantaneous frequency of the input signal. Thus small as well as larger input signal amplitudes whereon interference is superimposed can be discriminated adequately and reliably in order to minimize audible effects of leaving out interfered part of the input signal.

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# INTERFERENCE DETECTION CIRCUIT HAVING AMPLITUDE FREQUENCY DOMAIN DEFINED DISCRIMINATION

The present invention is concerned with an interference detection circuit comprising:

- gate means having a gate control for preventing interference in an inputted signal from being outputted, and
- 5       - control means coupled to the gate control for generating a gate control signal.

The present invention is also concerned with a method for detecting interference, wherein an input signal whereon interference is superimposed is prevented from being outputted by gating said input signal by means of a gate control signal.

10       Furthermore the present invention is concerned with a receiver, comprising a tuner means, a demodulator means having an input coupled with the tuner means and an audio output.

Such an interference detection circuit and method are commonly used in  
15   the video, or audio field, such as in receivers, car radios etcetera, but are also used in measuring equipment and radar appliances.

The generally known interference circuit uses the gate means to leave out that part of the inputted signals whereon interference is superimposed. That part is then replaced by a part not polluted with interference.

20       The known interference circuits suffer from the drawback that the amplitude of detected interferences have to exceed a fixed threshold in order to activate these circuits by generating the gate control signal. Some types of interferences have a small amplitude but can be very disturbing for a relatively weak signal emanating from for example a far away transmitter. Such interferences are badly detected by the known interference  
25   circuits.

Another problem in the prior art circuits is related to the fixing of the threshold. On the one hand this threshold has to be large enough to avoid false interference detection, whereas at the other hand this threshold should be low enough to detect annoying interferences.

30

The present invention aims at obviating these drawbacks by providing an interference circuit and a method for detecting interference which are capable of reliably detecting several types of interferences, and which allow to be implemented on a chip at a reasonable cost price.

5                    Thereto the interference detection circuit according to the present invention is characterised in that

the control means comprises:

- means for defining a discrimination curve in terms of magnitude and frequency, and
- 10                    - means for detecting whether the combination of the instantaneous magnitude and the instantaneous frequency in the inputted signal approaches the discrimination curve, in which case the control means generate the gate control signal.

Accordingly, the method for detecting interference is characterised in that  
15                    a discrimination curve is being defined in terms of magnitude and frequency, whereas the gate control signal is being generated if the combination of the instantaneous magnitude and instantaneous frequency in the input signal approach the discrimination curve.

Accordingly the receiver according to the invention is characterized in that the receiver further comprises an interference detection circuit according to one of the claims  
20                    1-8, which interference detection circuit is coupled with the audio output of the demodulator means.

The advantage of the interference circuit and interference detecting method according to the invention is that the advanced instantaneous magnitude (which is independent from its sign, i.e. the same for positive and negative amplitude) and frequency  
25                    dependent discrimination curve results in a optimum discrimination between interfered and non interfered inputted signals for several types of interferences. One type of interference, wherein a strong signal interferes with a desired weak signal, can now be discriminated optimally by specifically adjusting the definition of the discrimination curve in terms of its instantaneous magnitude versus instantaneous frequency behaviour in the amplitude-frequency  
30                    domain. In another type of interference wherein large signals having low frequencies suffer from small interferences, these small interferences will also be detected, whereas generally large signals suffering from relatively small interferences can at wish be left unaffected again by specifically defining the discrimination curve in said domain in order to reduce possible audible effects, when the interference circuit according to the invention is used to blank or

gate interferences in audio devices.

Interference circuits present in those audio devices have a time delay component for conveying the audio signal there through. Such a delay component is quite expensive due to the high requirements posed there on with respect to noise and distortion. It is an advantage of the present invention that it is less expensive because it does not have a delay component, but instead only has a control means for controlling the blanking of annoying interferences without the necessity to intervene otherwise on the audio signal itself.

One embodiment of the interference circuit according to the invention is characterised in that the means for defining a discrimination curve in terms of instantaneous magnitude and instantaneous frequency comprises a non linear transfer function means.

The advantage of this embodiment of the interference circuit according to the invention is that it provides a degree of freedom, wherein the design and form of the graph of the discrimination curve can be optimally matched to the wanted discrimination properties by choosing the non linear characteristics of these easily implementable components.

A further embodiment of the interference circuit according to the invention is characterised in that the means for defining the discrimination curve in terms of the instantaneous magnitude and the instantaneous frequency of the inputted signal is provided with a reference control input for influencing the position of the discrimination curve in the instantaneous magnitude versus instantaneous frequency domain.

This makes the discrimination between interfered and less or not interfered signals even adaptive to e.g. the instantaneous magnitude of the inputted signal.

One embodiment of the method according to the invention is characterised in that the gate control signal for activating the gating or blanking action is being generated if an arithmetic relation, in particular an addition or a product of the instantaneous magnitude and the instantaneous frequency of the input signal, approaches or crosses the defined discrimination curve.

Such an embodiment of the method according to the invention has the advantage that it can easily be accomplished by applying a non linear transfer function means.

A further embodiment of the method according to the invention is characterised in that after detection of an interference the sensitivity for future interferences is influenced during a period of time.

This is easily, but accurately done, by temporarily shifting the adaptive

discrimination curve in the amplitude-frequency domain, having the effect of preventing multiple triggering in noisy conditions.

These and other aspects and advantages of the present invention will be apparent and further elucidated with reference to the embodiments and figures described hereinafter. Similar elements in the separate figures carry the same reference numerals throughout these figures. In the drawing:

- Fig. 1 shows an example of a prior art interference detection circuit;
- Fig. 2 shows a discrimination curve in the instantaneous amplitude instantaneous frequency domain intended to elucidate the present invention;
- Fig. 3 shows one embodiment of the interference detection circuit according to the invention having a control means;
- Fig. 4 shows a graph of a possible transfer function of a non linear transfer function means applied in the interference detection circuit according to the invention;
- Fig. 5 shows a further control means for application in a second embodiment of the interference detection circuit according to the invention;
- Fig. 6 shows graphs of examples of relevant voltages in the embodiment of figure 5;
- Fig. 7 shows a still further control means for application in a third embodiment of the interference detection circuit according to the invention;
- Fig. 8 shows graphs of examples of relevant voltages in the embodiment of figure 7; and
- Fig. 9 shows a schematic diagram of a receiver provided with an interference detection circuit according to the invention.
- Fig. 10 shows a schematic diagram of an FM stereoreceiver provided with an interference detection circuit according to the invention.

Figure 1 shows an embodiment of a prior art interference detection circuit 1 integrated as an AM noise detection circuit. An audio signal  $V_{\text{audio}}$  whereon an interference signal  $V_{\text{interference}}$  is superimposed is applied to an input 2 of the detection circuit 1. Upon detection by a control means 3 of an interference in the audio signal on input 2 a gate means



4 is disabled, thereby blocking the input signal from being conveyed to output 5 of the interference detection circuit 1. The interference detection circuit 1 has a delay 6 connected between the input 2 and the gate means 4. The gate means 4 has a gate control 7 whereon a gate control signal is generated in order to be able to gate or block the input signal on input 2 on the right moment, once interference is detected and as long as it lasts. The control means 3 of the known interference detection circuit 1 comprises a high pass filter 8, a comparator 9, and a gate timing circuit 10 for generating the gate control or blanking signal on gate control 7 if only a positive going interference is detected which exceeds a  $V_{\text{threshold}}$ .

Figure 2 shows a graph of the instantaneous magnitude  $A_{\text{audio}}$  versus the instantaneous frequency  $F_{\text{audio}}$ , wherein a discrimination curve D is defined to elucidate the notion that input signals, either lie in a dashed area with normally expected instantaneous magnitude and instantaneous frequency, or lie outside that area in which case an interference will be detected. One could say that the instantaneous vector  $(A_{\text{audio}}, F_{\text{audio}})$  either lies inside, or outside the area defined by the discrimination curve.

Figures 3, 5, and 7 show embodiments of a relevant part of interference detection circuits 1, in particular of the control means 3, wherein the circuits 1 do not include a delay 6, but have instead a direct connection between input 2 and the gate means 4. These embodiments to be described comprises means 11 for defining a discrimination curve in terms of instantaneous magnitude and instantaneous frequency. These discrimination curve defining means comprises a non linear transfer function means 11 in the embodiments shown here. Of course such a discrimination curve could also be simulated or defined digitally e.g. by means of a suitable algorithm or subroutine implemented in a microprocessor.

Figure 4 illustrates a saturation like behaviour of the non linear transfer function means 11 showing  $V_{\text{satout}}$  versus  $V_{\text{satin}}$  as a function of a possibly applicable  $V_{\text{reference}}$  values of such means 11.  $V_{\text{reference}}$  provides the possibility in the graph of figure 2 to adapt the position of the discrimination curve D in the instantaneous magnitude versus instantaneous frequency domain. The directions of the opposite arrows P indicate such directions wherein the curve D may be shifted in dependence on e.g. the instantaneous amplitude of the signal input on 2. Applying the non linear means 11 yields an output signal  $V_{\text{discrimination}}$ , which is a non linear function of the product  $A_{\text{audio}}$ , read instantaneous magnitude, and  $F_{\text{audio}}$ , read instantaneous frequency. This product is only one possible arithmetic relation. Of course other arithmetic relations may be realised at wish, such as an addition or a more complicated and not symmetric relation between  $A_{\text{audio}}$  and  $F_{\text{audio}}$ . Such a relation may be realised by analog or digital means not further specified but within the reach of a skilled person. Such a

relation may then be made dependent on the parameter  $V_{\text{reference}}$  in order to facilitate the shifting of the discrimination curve  $D$  in said amplitude frequency domain.

The embodiment of figure 3 comprises a first loop means comprising a differential amplifier 12 having a first differential input 13 connected to the input 2 and a second differential input 14; the non linear element 11 interconnected between the differential amplifier 12 and an integrator / low pass filter means 15, whose output is connected to the second differential input 14. The means for detecting whether the combination of the instantaneous magnitude and the instantaneous frequency of the inputted signal approaches the discrimination curve comprises here the differential amplifier 12. After rectifying  $V_{\text{sat in}}$  by means of a rectifier 16  $V_{\text{discrimination}}$  results, which contains a measure with respect to the relative distance between the defined discrimination curve and the vector combination of the instantaneous magnitude and frequency in said domain or space. Note that this improved two dimensional combined discrimination is not influenced by the sign of the interference, whereas the prior art interference detection circuit only responded to interferences having a positive sign. The operation of the figure 3 embodiment is such that if the product of  $A_{\text{audio}}$  and  $F_{\text{audio}}$  approaches  $V_{\text{reference}}$  that, due to the inclination of the graph of figure 4,  $V_{\text{discrimination}}$  increases rapidly in the vicinity of the origin of the graph.

Note further that  $V_{\text{reference}}$  controls simultaneously the slope at small  $V_{\text{sat in}}$  and the saturation value of  $V_{\text{sat out}}$  at large  $V_{\text{sat in}}$ , resulting in a further improved interference detection behaviour both at small interferences superimposed on small input signals and at larger interferences superimposed on larger input signals.

In the embodiments to be described with reference to figures 5 and 7 effective use is made of  $V_{\text{reference}}$  which is generated by means of a second loop means being nested in the first loop means described earlier. The second loop means comprises an amplifier 17 being input by  $V_{\text{discrimination}}$  for determining the second loop gain, which amplifier 17 is connected to a low pass filter 18 for determining the dynamic behaviour of the second loop. The low pass filter 18 outputs the control signal  $V_{\text{reference}}$  for the non linear transfer function means 11. The operation of these embodiments, which make use of the second loop means is such that the discrimination level expressed by  $V_{\text{reference}}$  is for stationary audio signals automatically adjusted to the average audio signal strength  $V_{\text{audio}}$ . An interference will cause a sharp increase of  $V_{\text{discrimination}}$  resulting in a trigger signal for the blanking pulse at output 19 of comparator 9.

Figure 6 indicates what happens if a positive or negative interference arises in the audio signal  $V_{\text{audio}}$ . As a consequence  $V_{\text{discrimination}}$  peaks and due to the low pass

filter action in filter 18  $V_{reference}$  slowly returns to the level it had for stationary audio signals. This means that there is created a region of reduced sensitivity indicated RRS in figure 6, which prevents multiple triggering in noisy conditions, such as will arise more frequently with an ever increasing population density and corresponding potential annoying activity  
5 density.

Figure 7 shows a still more advanced embodiment, wherein amplifier 17 is connected to a cascade 20 of a low pass filter and an all pass filter. Here the start and the stop information for the blanking pulse on output 19 is directly derived from  $V_{reference}$  being the filtered version of  $V_{discrimination}$ .

10 Figure 8 shows that due to the all pass filter action  $V_{reference}$  has a negative precursor as soon as interference is detected. It remains negative during a time interval which is a function of the cut-off frequencies of the low pass and all pass filters, and a function of the second loop gain. These parameters can be adjusted such that a directly usable blanking pulse can be generated by the comparator 9, in which case a separate gate  
15 timing circuit can be dispensed with. The threshold voltage of the comparator 9 is zero. Its input polarity is chosen opposite to the embodiment shown in figure 5 where the variable threshold voltage of the comparator 9 has to be high in order to start the blanking pulse on output 19.

The first loop means will of course respond faster than the second loop  
20 means because the first loop means has to be able to kind of peak through the discrimination curve, whose position P follows the running average of the product of instantaneous magnitude and instantaneous frequency of the input signal. The second loop means, in particular its low pass filter characteristics, prescribe the time interval of the running average, which determines the position P.

25 Figure 9 shows a schematic diagram of a receiver 21, comprising a tuner means 22 coupled to an antenna 23, a demodulator means 24 having an input 25 coupled with the tuner means 22, and an audio output 26 for providing  $V_{audio}$  to the interference detection circuit 1, which circuit 1 is coupled between the output 26 and sound reproducing means, such as e.g. a loudspeaker S. In case of a stereophonic audiosignal comprising  
30 stereophonic left and right audiosignals  $V_{audio}$  and  $V_{audio}'$  outputted at audio outputs 26 and 26' of the demodulator means 24 an interference detection circuit 1' is coupled between the audio output 26' and sound reproducing means S'. The receiver 21 can be an AM mono- or stereo receiver or an FM receiver. In case of an AM receiver the demodulator means 24 comprises an AM detector. In case of an FM receiver the demodulator means 24 comprises an FM

detector as well as a stereo demultiplexer.

Fig. 10 shows a stereophonic FM receiver comprising elements corresponding to those of the receiver of fig. 9 which are likewise numbered. The tuner means 22 are connected to an FM demodulator 27, supplying a stereo multiplexsignal to the interference detection circuit 1. An output of the interference detection circuit 1 is coupled to a demultiplexer 28 for deriving the stereo left and right audio signals from the outputsignal of the interference detection circuit 1 and for supplying these signals to respectively left and right stereo sound reproducing means  $S_L$  and  $S_R$ .

## CLAIMS

1. An interference detection circuit comprising:
- gate means having a gate control for preventing interference in an inputted signal from being outputted, and
  - control means coupled to the gate control for generating a gate control signal,
- 5 characterised in that the control means comprises:
- means for defining a discrimination curve in terms of instantaneous magnitude and instantaneous frequency, and
  - means for detecting whether a combination of the instantaneous amplitude and the instantaneous frequency of the inputted signal exceeds the discrimination curve, in which case the control means generate the gate control signal.
- 10
- 15 2. The interference detection circuit of claim 1, characterised in that the means for defining a discrimination curve in terms of instantaneous magnitude and instantaneous frequency comprises a non linear transfer function means.
3. The interference detection circuit of claim 1 or 2, characterised in that the
- 20 means for defining a discrimination curve in terms of instantaneous magnitude and instantaneous frequency comprises a first loop means.
4. The interference detection circuit of claim 1,2 or 3, characterised in that the means for detecting whether the combination of the instantaneous magnitude and the
- 25 instantaneous frequency of the inputted signal exceeds the discrimination curve comprises a differential amplification means.
5. The interference detection circuit of claim 1,2,3 or 4, characterised in that the means for defining the discrimination curve in terms of the instantaneous magnitude and

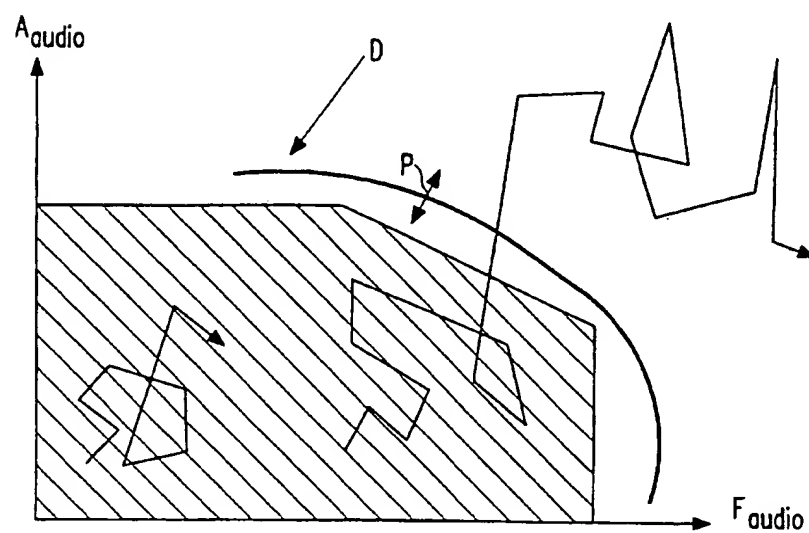
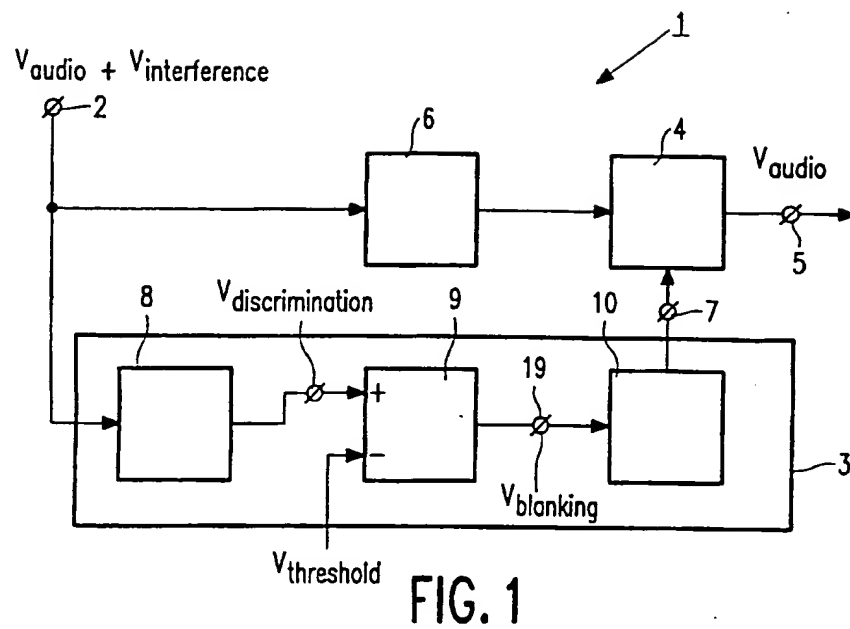
the instantaneous frequency of the inputted signal is provided with a reference control input for influencing the position of the discrimination curve in the instantaneous magnitude versus instantaneous frequency domain.

- 5 6. The interference detection circuit of claim 1,2,3,4 or 5, characterised in that the means for defining the discrimination curve in terms of the instantaneous magnitude and the instantaneous frequency of the inputted signal comprises second loop means.
7. The interference detection circuit according to one of the preceding claims  
10 referring back to claims 3 and/or 5, characterised in that the first and/or second loop means are nested loop means.
8. The interference detection circuit of claim 7, characterised in that the  
15 filter means comprises all pass filter means.
9. Method for detecting interference, wherein an input signal whereon  
interference is superimposed is prevented from being outputted by gating said input signal by  
means of a gate control signal,  
characterised in that  
20 a discrimination curve is being defined in terms of instantaneous magnitude and  
instantaneous frequency, whereas the gate control signal is being generated if the combina-  
tion of the instantaneous magnitude and instantaneous frequency of the input signal approach  
the discrimination curve.
- 25 10. Method according to claim 9, characterised in that the combination of the  
instantaneous magnitude and instantaneous frequency is based on an arithmetic relation.
11. Method according to claim 10, characterised in that the arithmetic relation  
is an addition or a product.
- 30 12. Method according to claim 9, 10 or 11, characterised in that the discrimi-  
nation curve is being defined adaptively.
13. Method according to claim 12, characterised in that the adaptation is

dependent on the instantaneous magnitude of the input signal.

14. Method according to claim 9, 10, 11, 12 or 13, characterised in that after detection of an interference the sensitivity for future interferences is influenced during a  
5 period of time.
15. Method according to claim 14, characterised in that the sensitivity for future interferences increases over the period of time.
- 10 16. Receiver, comprising tuner means, demodulator means having an input coupled with the tuner means and an audio output, characterized in that the receiver further comprises an interference detection circuit according to one of the claims 1-8, which interference detection circuit is coupled with the audio output of the demodulator means.
- 15 17. FM receiver, comprising, tuner means, frequency demodulator means and demultiplexing means, characterized in that the receiver further comprises an interference detection circuit according to one of the claims 1-8, which interference detection circuit is coupled with the audio output of the demodulator means is coupled between the frequency demodulator means and the demultiplexer means.

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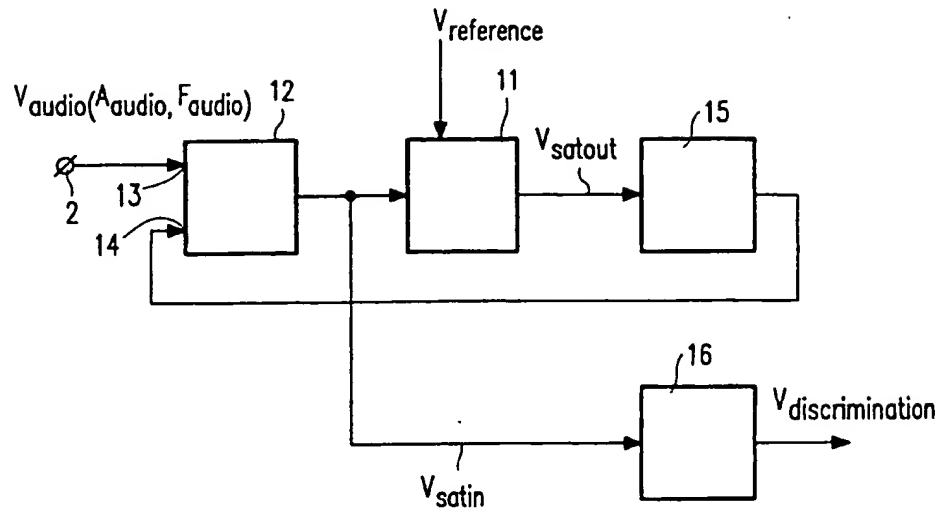


FIG. 3

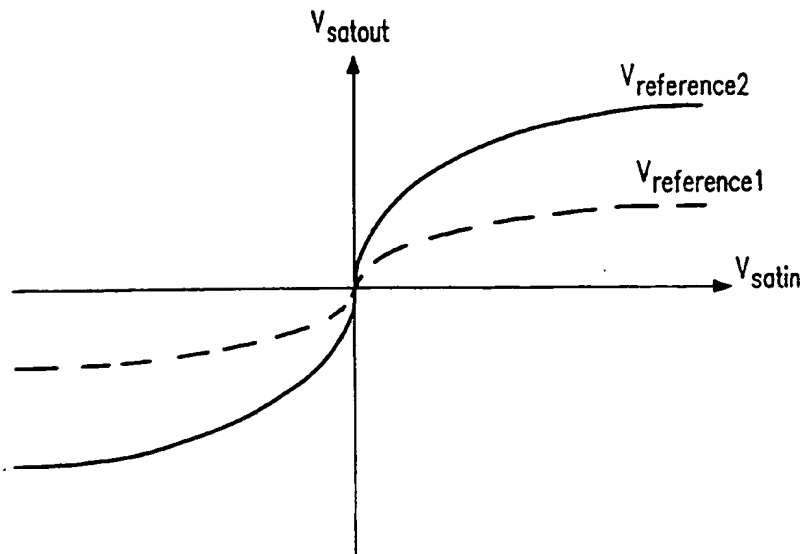


FIG. 4

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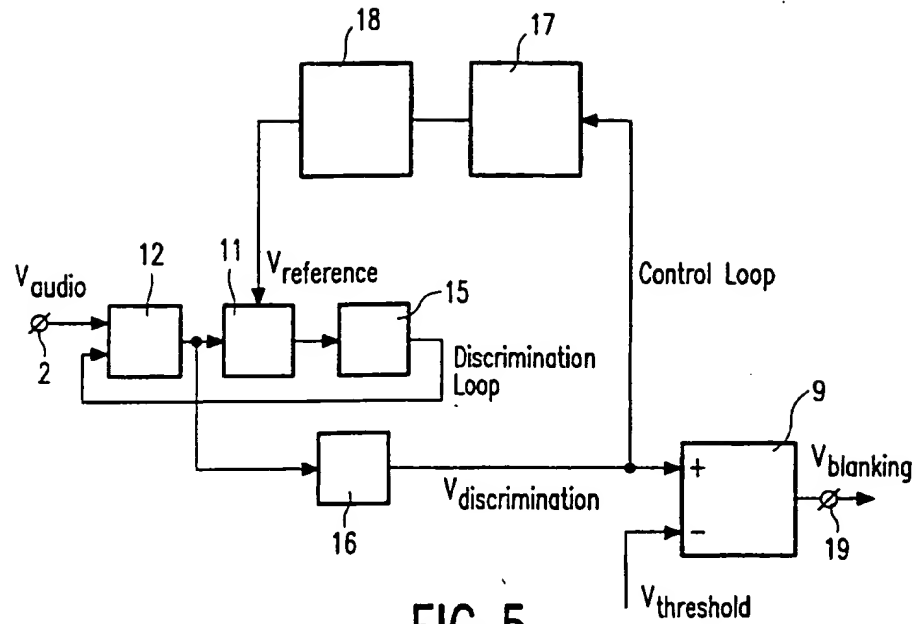


FIG. 5

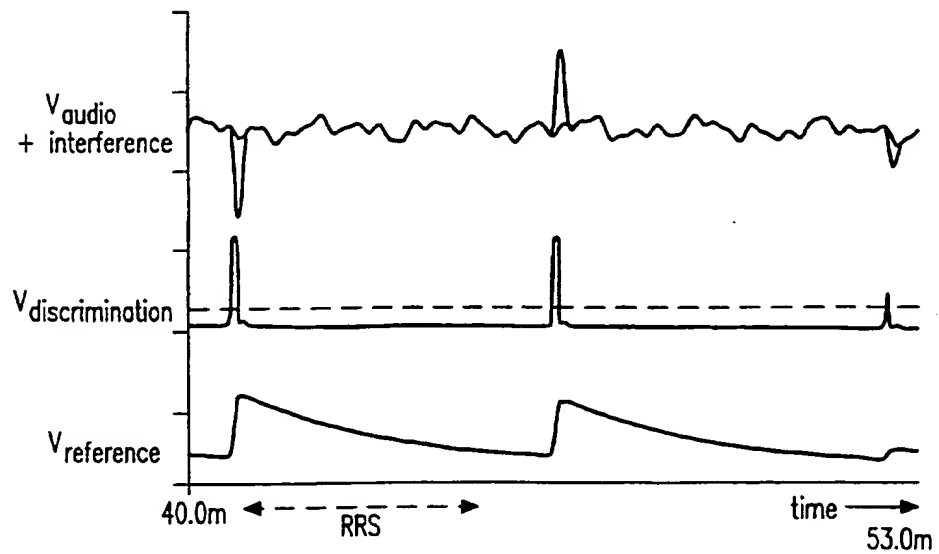


FIG. 6

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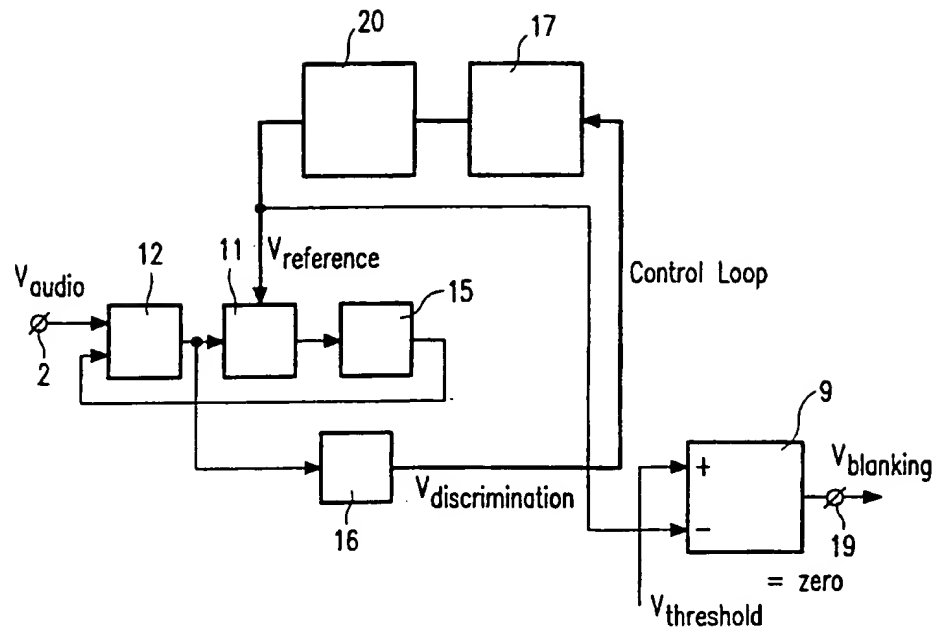


FIG. 7

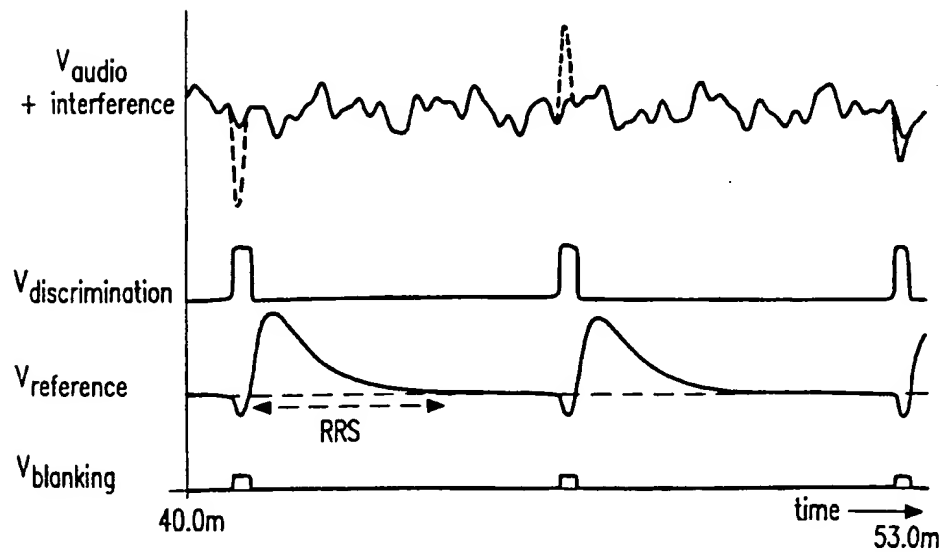


FIG. 8

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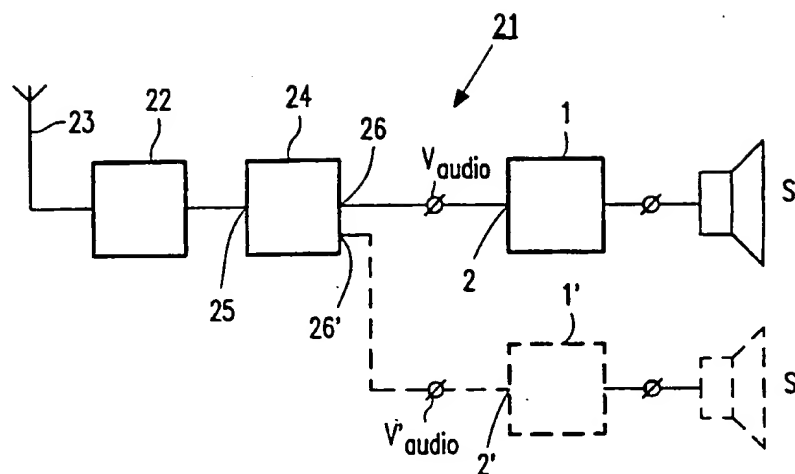


FIG. 9

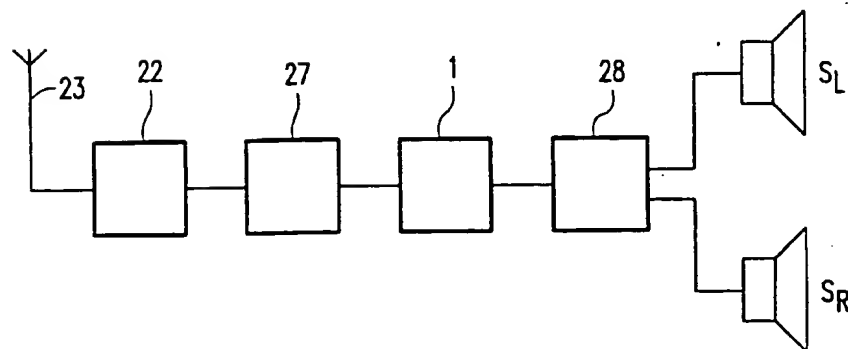


FIG. 10

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB 97/00874

## A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04B 1/10

According to International Patent Classification (IPC) or to both national classification and IPC

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## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4525868 A (KOUZOU KAGE ET AL), 25 June 1985 (25.06.85), column 1, line 39 - line 68, figure 2 --	1-17
A	EP 0597525 A1 (PHILIPS ELECTRONICS N.V.), 18 May 1994 (18.05.94), figure 1, abstract --	1-17
P,A	WO 9723959 A2 (PHILIPS ELECTRONICS N.V.), 3 July 1997 (03.07.97), page 2, line 20 - page 4, line 6 -----	1-17

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